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April 22, 1994

JILL A. STERN
(202) 663-8380

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W.
Washington, D.C. 20554

Re: GEN Docket No. 90-314

Dear Mr. Caton:

On behalf of Spatial Communications, Inc. and ArrayComm, Inc., I am transmitting herewith an original and eleven copies of their joint comments in the above-referenced proceeding. These comments are filed in connection with the PCS Task Force hearings held on April 11 and 12, 1994, and should also be associated with the petitions for reconsideration of the Second Report and Order in GEN Docket No. 90-314.

Should there be any questions concerning this matter, kindly communicate with the undersigned.

Sincerely,

Jill Abeshouse Stern
Counsel to Spatial Communication, Inc.
and ArrayComm, Inc.

cc: Gail Brown
JAS:pad

Enclosures

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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Amendment to the Commission's Rules to Establish New Personal Communications Services	)	GEN Docket No. 90-314

JOINT COMMENTS OF SPATIAL
COMMUNICATIONS, INC. AND ARRAYCOMM, INC.

Spatial Communications, Inc.("SCI") and ArrayComm, Inc. ("ArrayComm"), by their attorneys, hereby submit joint comments in the above-captioned proceeding. These comments are filed in support of the December 8, 1993 "MCI Petition for Partial Reconsideration and Clarification" and the "Petition for Reconsideration" of Telocator, The Personal Communications Industry Association ("PCIA"), of the Second Report and Order in GEN Docket No. 90-314. These comments are also submitted in response to the hearings held on April 11 and 12, 1994 by the PCS Task Force, and the views expressed therein.

I.

SCI and it parent company, ArrayComm, are the developers of the innovative Spatial Division Multiple Access ("SDMA") technology. SDMA relies upon patented algorithms to implement "smart antennas" that track mobile users and selectively direct RF energy toward the intended receivers. Directional

transmission and reception using smart antennas provides significant public benefits including increased spectrum efficiency, reduced costs of implementing and providing PCS services, reduced RF interference and radiation exposure, and inherent 911 emergency location services.

The technical feasibility and public benefits of SDMA technology have been confirmed by independent technical experts and by diverse government entities, including the Advanced Research Projects Agency which recently awarded a Technology Reinvestment Project (TRP) grant to ArrayComm for further development of SDMA technology. 1/ In addition, experimental testing under actual field conditions, using prototype equipment, has demonstrated the technical feasibility of SDMA technology.

II.

In these comments, SCI and ArrayComm focus on a critical issue that was raised in the MCI, PCIA and other industry petitions, and largely overlooked in the Task Force hearings. This issue can be simply stated: large-scale PCS implementation will not be economically feasible unless permissible cell size is increased. SCI and ArrayComm believe that directional

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1/ Affidavits of technical experts have been previously submitted in this proceeding, and are resubmitted herewith for the Commission's convenience. In addition, letters supporting ArrayComm's TRP filing are also submitted herewith in Exhibit 1.

transmission and reception offer the most effective and efficient means of increasing coverage area -- from an economic, technical and public interest standpoint. Numerous operators and manufacturers share this view.

Directional transmission and reception, such as demonstrated by ArrayComm, offers operators the ability to improve service quality and increase user capacity, while reducing the cost of service to the public. 2/ As a practical matter, smart antennas are the means of harmonizing the industry's objectives of increased power (larger coverage areas and increased capacity) with the Commission's interests in minimizing interference and reducing radiation exposure.

Among other benefits, use of smart antennas significantly increases the number of channels that a base station can serve, by reducing the required amount of transmitted power from both the base stations and the mobile units, overcoming multiple signal reception problems, and by allowing multiple users to occupy the same frequency, time slot or code at the same time. Directional transmission can be used to minimize interference throughout the system, including problems associated with fixed microwave users in the same band. Moreover, directional transmission reduces radiation risks.

2/ Attached hereto as Exhibit 2 is information demonstrating the potential cost savings to the operator.

While SCI and ArrayComm believe that directional transmission and reception should be required as a basic PCS system architecture, at a minimum, the Commission should facilitate the use of smart antennas by refining the power limitations for PCS systems as more fully discussed below and in the associated technical exhibit.[3/]

III.

In their petitions, PCIA and MCI requested that the Commission authorize an increase in base station EIRP limits from 100 W to 1600 W, in order to facilitate use of "smart antenna" concepts.[4/] These petitioners state that, while mobile units are limited to 2 W EIRP average, "smart antenna" technology could be used to balance the links if 1600 W base station EIRPs were allowed. Furthermore, the petitioners point out that the larger coverage areas afforded by the higher base station EIRPs are necessary for the commercial viability of PCS.

SCI and ArrayComm agree with this industry assessment that increases in base station power limits are critical to the viability of PCS. While generally supporting the proposals of

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3/ The second-generation SDMA processor under development by ArrayComm will apply to all proposed PCS air-interface standards, both analog and digital. The logarithms and hardware configuration could be incorporated by any manufacturer, regardless of RF modulation format, desiring to utilize this break-through technology.

4/ See, e.g., PCIA Petition at 3-4; MCI Petition at 6-8.

PCIA, MCI and others, SCI and ArrayComm believe that the public interest would be best served by adopting an approach that combines the concept of peak directional radiated power and average radiated power.

Under this approach, higher power would be permitted by concentrating a smaller amount of total radiated power toward the intended user, not through omnidirectional transmission. Even though the power would be directed toward users, currently accepted RF exposure standards would be met as shown in the attached technical exhibit.

To assist the FCC in developing appropriate guidelines to facilitate the use of directional transmission, a detailed technical discussion is provided in the attached exhibit.[5/] In the technical exhibit, modifications to the standard definitions commonly used by the Commission are proposed to facilitate use of directional transmission, while ensuring that maximum RF exposure is well below accepted limits. The exhibit provides tables for calculating the permissible average and peak directional radiated powers. The Commission should adopt these standards in order to provide flexibility to PCS licensees, ensure that RF exposure

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5/ It bears emphasis that the current power limitations adopted in this proceeding do not preclude smart antennas or SDMA technology. However, these power limitations do not allow operators to achieve the full economic (and public) benefits offered by this technology because of the limited coverage area now permitted. The rule changes proposed herein would encourage use of directional transmission and reception, and facilitate use of this innovative and spectrally-efficient technology.

guidelines as adopted by the Commission are met, and facilitate use of smart antenna technology by those operators and manufacturers who wish to do so.

Conclusion

SCI and ArrayComm support the petitions of PCIA, MCI and others urging the Commission to revise the proposed power limitations for PCS systems in order to ensure expeditious deployment of cost-effective and high-quality PCS service. To facilitate use of smart antennas, and the public benefits they will provide, SCI and ArrayComm recommend that the Commission adopt power limitations that combine the concept of total radiated power and peak radiated power as more fully set forth in the associated technical exhibit.

Respectfully submitted,

SPATIAL COMMUNICATIONS, INC.
ARRAYCOMM, INC.

By: Jill Abeshouse Stern

Jill Abeshouse Stern

SHAW, PITTMAN, POTTS & TROWBRIDGE
2300 N Street, N.W.
Washington, D.C. 20037
(202) 663-8000

Their Attorney

April 22, 1994

Exhibit 1

Clint Cooper
Executive Director
Corporate Strategy-Technology

PacTel Corporate Plaza
2999 Oak Road, MS 600
Walnut Creek, CA 94596
(510) 210-3633
FAX (510) 210-3634

PACIFIC TELESIS
Corporation

A Pacific Telesis Company

March 31, 1994

Dr. Richard H. Roy
President
Arraycomm
3885 Scott Blvd.
Bldg. 4, Suite 108
Santa Clara, Ca. 95054-3013

Dear Richard,

I would like to thank you for the opportunity to view your field demonstrations of SDMA.

I was very impressed with progress Arraycomm has made over the past year, especially in the area of range enhancement and capacity solutions for the 1900 MHz band. In general, AirTouch believes that exploitation of the spatial domain by use of intelligent array antennas will be a key enabling technology for new wireless infrastructure deployments.

AirTouch supports the efforts of Arraycomm that aim to reduce infrastructure costs through range and capacity enhancements offered by SDMA techniques.

Please keep me informed of your progress.

Sincerely,

Clint Cooper
Executive Director - Technology Strategy
AirTouch Communications, Inc.

BELLSOUTH
ENTERPRISES, INC.

Eric F. Ensor
Assistant Vice President
Worldwide Wireless Strategy

Room 8D01
1100 Peachtree Street, NE
Atlanta, Georgia 30309
(404) 249-4375
(404) 249-4488 Fax

July 21, 1993

Mr. Martin Cooper
Chairman and CEO
ArrayComm, Inc.
3225 Scott Blvd., Bldg. 4
Santa Clara, CA 95054-3013

re: BellSouth's PCS development and ArrayComm's SDMA technology

Dear Marty:

Thank you for the hospitality you extended to the members of our organization that visited your facility recently. They were impressed by the demonstration of SDMA technology you presented. It reinforces our belief that *smart antenna* technology such as SDMA will play a significant role in wireless communication systems of the future.

As you are aware, we are in the process of planning a next generation (PCS) wireless system which we will be developing over the course of the next several years. We would like to take this opportunity to inform you of some decisions made within our organization in this regard. It is our intent to work closely with several major telecommunication manufacturers and operators for *the design, development* and manufacture of a PCS network to operate in the 1800 *MHz* band. Among various other technical requirements we expect the companies to meet will be that of provisions for inclusion of *smart antenna* technology. We view SDMA's potential for increasing signal quality, lowering mobile-unit transmitter powers, protecting incumbent microwave users in the band of interest, and increasing coverage area as important assets in providing us the flexibility to design a cost-effective PCS network which meets the needs of our customers. In an effort to accelerate the development of this technology, we are encouraging manufacturers to enter into discussions with companies such as ArrayComm.

We are looking forward to working closely with all our developers and suppliers in developing a high-quality wireless network which will allow our organization to maintain its leadership position in this exploding worldwide marketplace.

Sincerely,

Eric Ensor

1990 North Mayer Lane, Suite 300
Walnut Creek, California 94598-2406
(510) 210-4800
Fax (510) 210-4806

TELESIS TECHNOLOGIES LABORATORY.

A Pacific Telesis Company

July 23, 1993

Mr. Martin Cooper
Chairman and CEO
ArrayComm, Inc.
3225 Scott Blvd., Bldg. 4
Santa Clara, Ca 94054-3013

Dear Martin,

I would like to take this opportunity to thank you for arranging this weeks meeting at your facility. The demonstration conducted by your team of SDMA technology was quite impressive.

As you know, Telesis Technologies Laboratory is investigating Personal Communication Services (PCS) for both Pacific Telesis business units (Pacific Bell and PacTel Corporation). From your demonstration it appears that the application of SDMA technology in new PCS networks could be very promising.

We are having internal discussion in our organization on the development of PCS technologies and will be discussing SDMA and its potential application.

Again, I want to thank you for the demonstration. I look forward to a continuing dialog with you on the direction and development of your SDMA technology.

Best Regards,

Limond Grindstaff
Executive Director

LG/bmc

Jack L. Greesingh
Vice President
General Manager

Raytheon Company
Electromagnetic Systems
Division
Goleta CA 93117-3197

805 967 5511
FAX 805 964 8115

Raytheon

20 July 1993

Dr. Richard H. Roy
President, ArrayComm, Inc.
3255 Scott Blvd. Bldg. 4
Santa Clara, CA 95054-3013

Dear Dr. Roy:

Raytheon has been briefed by ArrayComm regarding their SDMA technology for wireless telecommunications.

We believe that the proposal by your team can enhance the cellular telephone industry. As you know, Raytheon, TRW, Honeywell, NASA and USAF have formed the Signal Processing Consortium for producing broadband modules for 21st Century Digital Telecommunication markets such as yours. It is the intent of our Consortium to work closely with your company, thus ensuring U.S. leadership in this pervasive technology area.

Raytheon is interested in maintaining contact with ArrayComm and would like to support the development of your SDMA technology for applications in the international telecommunication market.

Sincerely,

Jack L. Greesingh

[redacted]

Mobile Communications Centre
32 avenue Kléber
92707 COLOMBES CEDEX
France

Ref CD/kr/93.538
Date 16/07/93

Claude Déchaux
tel. +33 (1) 46.52.12.06
fax. +33 (1) 46.52.80.17

Mr. Martin Cooper
Chairman and CEO
ArrayComm, Inc.
3255 Scott Blvd, #4-103
Santa Clara, CA 95054

Dear Marty

I would like to thank you for your hospitality during my recent visit to your facility. The demonstration of your SDMA technology was highly interesting.
We at Alcatel believe that smart antenna technology such as SDMA will play an important role in future wireless communication systems.

I would also like to take this opportunity to inform you that, as Alcatel is aggressively pursing major cellular and PCS opportunities worldwide, several companies in the Alcatel group will contact you in the near future to discuss possible integration of ArrayComm's technology into their products and systems.

In particular the application of SDMA technology to the enhancement of performances of DCS 1800 systems seems very appropriate and would speed up their acceptance in the worldwide market.

Yours sincerely

Déchaux

C. Déchaux
Director of Strategy
Mobile Communications Business

AFFIDAVIT

I, Guy Jounmeille do hereby declare as follows:

1. I am currently Senior Engineer of LCC LLC and have held my current position for 1 year.

2. I have more than 11 years experience in the design and development of telecommunications systems. Previous positions include the following:

   - Research Engineer of ONERA (France), responsible for antenna arrays conception, design and experimentation, and propagation modeling,
   - Project Manager at Alcatel Radiotelephone (France), for radio engineering tool development,
   - Director of Technical Development at France Telecom, responsible for all technical aspects of a GSM National Network Radio Engineering and Deployment.

3. In my current position, I am responsible for supervising PCS technologies trends analysis and associated radio engineering tools development.

4. In my capacity as Senior Engineer of LCC, I have reviewed theoretical and practical bases of ArrayComm's SDMA technology and witnessed field demonstrations thereof.

5. On the basis of my review of the relevant literature and observations, it is my expert opinion that ArrayComm's SDMA technology is technically feasible and represents a truly innovative approach to increasing spectral efficiency. Deployment of SDMA technology will substantially reduce the amount of radiated (RF) power (over current technologies and for the same cell size) required per link to establish reliable communications through directional transmission from and directional reception by base stations, and will allow multiple wireless links to share the same spectrum in the same cell. The benefits include lower power handset and base station RF transmissions, and a substantial increase in spectral efficiency. In the context of PCS, deployment of SDMA technology will facilitate more efficient use of available spectrum for all service providers.

Under penalty of perjury, the foregoing is true and correct to the best of my knowledge.

LCC LLC

Name : Guy Jounmeille

Sign 

Title : Senior Engineer
Date : 30 March, 1994

AFFIDAVIT

I, Stuart Jeffery do hereby declare as follows:

1. I am currently Vice President of Kycom, and have held my current position for over one year.

2. I am a duly qualified engineer, whose qualifications are a matter of record before the Federal Communications Commission. I hold the following degrees:

   BS Physics, Ohio State University
   Graduate Studies in Electrical Engineering, University of Colorodo
   Exective MBA, Northeastern Universtiy

   I hold a First Class FCC Radiotelephone License.

   I have more than 25 years experience in the design and development of telecommunications systems. Previous positions include the following:

   Director of Network Systems, GTE Corporation, Waltham, MA.
   Director of EW Systems, GTE Corporation, Mt View, CA.
   Manager of ESM Systems, ERA, a division of E-Systems, Reston, VA.
   Research Physicist, NBS, Boulder, CO.
   Assistant Chief Engineer, Ohio State University Telecommunications Center, Columbus, OH.

3. In my current position, I am responsible for supervising the design and development of Kycom's PCS telecommunications network.

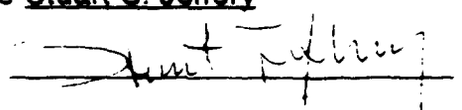
4. In my capacity as Vice President of Kycom, I have fully reviewed the theoretical and practical bases of ArrayComm's SDMA technology and witnessed field demonstrations thereof.

5. On the basis of my review of the relevant literature and first-hand observations, it is my expert opinion that ArrayComm's SDMA technology is technically feasible and represents a truly innovative approach to increasing spectral efficiency. Deployment of SDMA technology will substantially reduce the amount of radiated (RF) power (over current technologies) required per link to establish reliable communication through directional transmission from and directional reception by base stations, and will allow multiple wireless links to share the same spectrum in the same cell. The benefits include lower power handset and base station RF transmissions, and a substantial increase in spectral efficiency. In the context of PCS, deployment of SDMA technology will facilitate more efficient use of available spectrum for all service providers, in addition to alleviating some of the OFS coexistence issues by substantially reducing contemplated exclusion zones.

Under penalty of perjury, the foregoing is true and correct to the best of my knowledge.

Kycom

Name Stuart S. Jeffery

Sign 

Title Vice President of Engineering, Kycom

Date March 29, 1994

AFFIDAVIT

I, George D. Geotsalitis do hereby declare as follows:

1. This testimony is being provided solely for the purpose of being used in conjunction with ArrayComm's pending FCC filing, and in no other instance.

2. I am currently Manager of PCS Standards for the United States Cellular Corporation, and have currently held my position for four (4) months.

3. I have more than 22 years of experience in the design and development of telecommunications systems. Previous positions include the following:

   Assistant Director, Standards, Ameritech Cellular
   Manager, Instruction/Development, Bellcore
   Manager, Transmission Engineering, Illinois Bell
   Manager, Technical Planning, Illinois Bell

4. In my current position, I am responsible for participation in the development of standards for PCS.

5. In my capacity as Manager PCS Standards, I have fully reviewed the theoretical and practical basics of ArrayComm's SDMA technology and witnessed a field demonstration thereof.

6. On the basis of my review of the relevant literature and first-hand observations, it is my expert opinion the ArrayComm's SDMA is technically feasible and represents a truly innovative approach to increasing spectral efficiency. Deployment of SDMA technology will substantially reduce the amount of radiated (RF) power (over current technologies) required, per link, to establish reliable communication through directional transmission from and directional transmission by base stations, and will allow multiple wireless links to share the same spectrum in the same cell. The benefits include lower power handsets and base station RF transmissions, and a substantial increase in spectral efficiency. In the context of PCS, deployment of SDMA technology will facilitate more efficient use of available spectrum for all service providers, in addition, to alleviating some of the OFS coexistence issues by substantially reducing contemplated exclusion zones.

Under penalty of perjury, the following is true and correct to the best of my knowledge.

US Cellular Corporation

Name George D. Geotsalitis
Sign George D. Geotsalitis
Title Manager, PCS Standards
Date March 28, 1994

AFFIDAVIT

I, Dennis M. Rucker do hereby declare as follows:

1. This testimony is being provided solely for the purpose of being used in conjunction with ArrayComm's pending FCC filing, and in no other instance.

2. I am currently Director of Engineering for the United States Cellular Corporation, and have currently held my position for nine (9) months.

3. I am a duly qualified engineer, whose qualifications are a matter of record before the Federal Communications Commission. I hold the following degrees:

   BSEE, Purdue, 1972

   I have more than 22 years of experience in the design and development of telecommunications systems. Previous positions include the following:

   Senior Director, Science & Technology, Ameritech Cellular

4. In my current position, I am responsible for supervising the design and installation of cellular telecommunications networks on a nationwide basis.

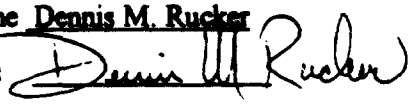
5. In my capacity as Director of Engineering, I have fully reviewed the theoretical and practical basics of ArrayComm's SDMA technology and witnessed a video taped demonstration thereof, and will be participating in a field demonstration.

6. On the basis of my review of the relevant literature and first-hand observations, it is my expert opinion the ArrayComm's SDMA is technically feasible and represents a truly innovative approach to increasing spectral efficiency. Deployment of SDMA technology will substantially reduce the amount of radiated (RF) power (over current technologies) required, per link, to establish reliable communication through directional transmission from and directional transmission by base stations, and will allow multiple wireless links to share the same spectrum in the same cell. The benefits include lower power handsets and base station RF transmissions, and a substantial increase in spectral efficiency. In the context of PCS, deployment of SDMA technology will facilitate more efficient use of available spectrum for all service providers, in addition, to alleviating some of the OFS coexistence issues by substantially reducing contemplated exclusion zones.

Under penalty of perjury, the following is true and correct to the best of my knowledge.

US Cellular Corporation

Name Dennis M. Rucker

Sign 

Title Director of Engineering

Date March 28, 1994

Exhibit 2

SDMA-ENHANCED PCS CELL-SITE ECONOMICS
Cost Per Voice Channel Estimation

	Scenario 1	*Scenario 2*	*Scenario 3*
Cell Configuration			
No. of frequency channels/cell	1	4	8
No. time slots/frequency	7	8	8
Spatial capacity increase factor/time slot	3	3	4
No. of voice channels/cell	21	96	256
Mcomplex/sec/voice channel	0.04	0.03	0.03
SDMA Processing Power Requirements			
Antenna reuse ratio	0.3	0.3	0.4
No. of antennas	10	10	10
DF updates/sec/frequency	10	10	10
Mflops/DF update/frequency	0.07	0.07	0.08
DF processing speed (Mflops)	20	20	20
No. DF processors required	1	2	3
Vector chip speed (Mflops)	5	5	5
No. of vector chips	1	3	7
Power Amplifier Requirements			
Reference System Design			
Average ERP/voice channel (watts)	7	6	6
Antenna gain/element (dBi)	9	9	9
Antenna cable/coupling loss (dB)	3	3	3
Power combiner output/channel (watts)	2	2	2
Power combiner output (watts)	**37.68**	**150.71**	**401.90**
1 dB compression pt power (watts)	119.15	950.94	4019.02
SDMA Efficiencies w/ PA Linearity			
Total power/total reference power	0.1	0.1	0.1
Power/antenna/total reference power	0.01	0.01	0.01
PA Composite power/1dB compression pt power (dB)	-5	-8	-10
Required PA power/element			
Composite power (watts)	**0.38**	**1.51**	**4.02**
1 dB compression pt power (watts)	1.19	9.51	40.19
Component Costs (large volume)			
Antenna element			
Up converter	$20	$20	$20
Power amplifier	$10	$20	$30
Down converter	$20	$20	$20
Digitizer	$200	$200	$200
Antenna	$50	$50	$50
TOTAL	$300	$310	$320
DF processor chip	$300	$300	$300
Digital filter/decimator	$20	$20	$20
Vector multiplier chip	$20	$20	$20
Digital interpolator	$20	$20	$20
Manufactured cost/component cost			
Antenna system	250%	250%	250%
DF processor boards	1000%	1000%	1000%
Digital receiver/transmitter boards	1000%	1000%	1000%
TOTAL SYSTEM COST			
Antenna subsystem	$7,500	$7,750	$8,000
DF subsystem	$3,000	$6,000	$9,000
Digital receiver subsystem	$4,400	$17,600	$35,200
Digital transmitter subsystem	$1,800	$7,200	$19,200
TOTAL	$16,700	$38,550	$71,400
COST PER VOICE CHANNEL	**$795**	**$402**	**$279**

SDMA-ENHANCED PCS ECONOMICS
Overall Base Station Relative Costs
(Neglecting Recurring Costs)

SDMA System Parameters	Scenario 3A	Scenario 3B
Number of antennas	10	10
Spatial capacity increase factor	4	4
Coverage area increase factor	**4**	**6.5**
Coverage radius increase factor	2.00	2.55
Power loss (1/R^3.85) (dB)	-12.00	-15.00
SDMA processing gain		
Antenna array gain (dB)	10.00	10.00
Interference reduction (dB)	10.00	5.00
TOTAL SDMA Receiver Gain (dB)	20.00	15.00
Net Uplink SINR Improvement (dB)	**8.00**	**0.00**
RF Hardware Related Costs		
Estimated Conventional Cell-Site Cost ($)	$135000.00	$135000.00
Additional Infrastructure Cost/Site ($)	$35000.00	$35000.00
Conventional Base Station RF Costs ($)	$170000.00	$170000.00
Conventional Base Station Cost Multiplier	**4**	**4**
Total cost per Conventional Base Station ($)	$680000.00	$680000.00
SDMA Additional Cost ($)	$71400.00	$71400.00
SDMA related infrastructure costs/site ($)	$40000.00	$40000.00
Total SDMA Additional Costs/Site ($)	$111400.00	$111400.00
Average no. conventional sites eliminated by SDMA	**3**	**5.5**
Fraction of conventional sites required with SDMA	**25.00%**	**15.38%**
SDMA Overall Base Station Relative Cost	**29.10%**	**17.90%**

Scenario 3A: Quality improvement (fixed capacity)
Scenario 3B: Infrastructure complexity reduction (fixed quality)

		[illegible]		SDMA	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
City	3080 km^2	0.5 km	5922	0.7 km	2001
Urban	57750 km^2	1.5 km	8170	3.0 km	2042
Rural	3224170 km^2	4.0 km	5482	10.0 km	877
Totals	3285000 km^2		17574		[illegible]
TOTAL COST			[illegible]		$1900M

Table 1-1: Cost Advantage of SDMA over Conventional DCS-1800 Systems

Exhibit 3

Broadband PCS
Radio Frequency Emissions Proposal
Revision 1.3

R. Roy, M. Goldburg
ArrayComm, Inc.
20 April 1994

TEL: (408) 982-9080 FAX: (408) 982-9082
email: dick@arraycomm.com

1. Introduction

This document is a draft of proposed rules for limiting the radio frequency (RF) emissions of broadband PCS base stations and mobile units. In the Federal Communications Commission's (FCC) Second Report and Order 93-451 released 22 October 1993, a 100W per channel power limit (EIRP) was adopted as the base station EIRP and 2W was adopted as the mobile (handheld) unit peak EIRP limit. The statement was also made that the intent of the rules was to promote innovation through flexibility (cf. 93-451, section 137, page 56). The changes proposed herein reflect this sentiment. Rather than defining limits on a per carrier/channel basis which allocates more power per hertz to narrower bandwidth channels, all bandwidths are treated equally.by allocating power on a per hertz basis. Those with more hertz get more power. Subject to the constraint that the maximum possible RF exposure under worst possible conditions be lees than currently accepted guidelines, and under the premise that all spectrum should be treated equally in terms of information carrying potential, maximum flexibility is afforded by these proposed limits to allow for a more cost effective roll-out and more timely deployment of PCS systems.

There is no intent in this document to repeat the cogent arguments made by the numerous petitions for increased base station power limits including MCI, Telocator (PCIA), Northern Telecom, APC, Ameritech, Motorola, Pacific Bell, U.S. West, and others. Therein, substantial justification for increasing base station powers by over an order of magnitude are presented. Succinct arguments concerning technical aspects (balancing of the forward and reverse links for primary voice service), reduced interference to other fixed services (microwave users), and the substantial economic benefits from higher base station powers are presented. Furthermore, substantive arguments are presented for the introduction of a higher power mobile unit class which we support as well.

That increased base station transmit power is actually necessary for PCS to compete with cellular service was elegantly stated and substantively supported by Telocator, Northern Telecom and MCI in their filings. Northern also commissioned MLJ to do a study of microwave interference which concluded that higher power limits could actually reduce

the interference problem (by giving increased flexibility in site location), and that new advanced antenna technologies were becoming available that could even further reduce the interference problem through intelligent signal processing. ArrayComm has built and successfully tested a prototype of just such a system. Furthermore, these intelligent antenna systems actually lead to reduced RF exposure to the public through directive transmission to and directive reception from mobile units, allowing mobile units to operate at substantially lower powers on average.

These arguments are so compelling that it is hard to imagine that higher base station powers will not be allowed. It is the intent of this document to propose slight alterations to currently accepted definitions of parameters for discussing power limits, and to propose some appropriate limits based thereon. The new definitions provide the flexibility and equality the FCC is seeking in treating operators equally (in proportion to their allocated bandwidth), and not tending to favor any specific modulation format over another. The basic idea is that RF exposure guidelines, both instantaneous and long-term average, lead to base station and mobile power limits, otherwise subject to noninterference criteria with primary users of the band, operators are given an even playing field upon which to design their systems with maximum flexibility.

2. Preliminaries

The intrinsic value of RF spectrum is its information-carrying capacity. This capacity is a function of the power used for signal transmission, the occupied bandwidth, and the distribution of noise power in the band. To ensure that all licensed bandwidths are accorded equitable treatment regardless of chosen modulation format while simultaneously promoting spectral efficiency, rules governing limitations on transmitted power should be expressed in units of power per unit bandwidth. Power limits for a given allocated bandwidth are obtained by simply multiplying by the allocated bandwidth. Thus, independent of modulation format, an operator allocated 20 MHz of spectrum has an aggregate power limit twice (and therefore twice the information carrying capacity) that of an operator with a 10 MHz allocation. Subject to temporal and spatial peak limitations, the operator can distribute this power so as to maximize efficiency throughout his network.

To ensure public safety, the power of transmissions from all base stations in a given area must be limited in terms of long term averages over space and time, short term bursts in time, and concentrations in space (using directive antennas). These limits are set with regard to worst case conditions, i.e., assuming that if intelligent antennas are employed, all users are in the same location at the same time so that each receives the cumulative field strengths of all users as is the case for omni-directional antenna systems. These considerations naturally lead to the necessity for limitations on the peak directional power per unit bandwidth. While use of intelligent antenna systems is not required, antenna systems that can direct power toward users reduce RF exposure to the public compared to current omnidirectional transmission systems by the amount of power gain of the intelligent antenna system assuming a uniform long term average angular distribution of users.